ATLAS OF MARS 1:5,000,000 GEOLOGIC SERIES CASIUS QUADRANGLE M 5M 48/270 G, 1978 I-1038 (MC-6)

GEOLOGIC SUMMARY

INTRODUCTION

Geologic units of the martian surface are subdivided on the basis of surface morphology, albedo, and crater distribution and are placed in a stratigraphic sequence following principles of superposition, crosscutting relations, and, to a degree, crater density.

PHYSIOGRAPHIC SETTING

The Casius quadrangle (30° N to 65° N lat; 240° W to 300° W long) is one of the northern tier of Lambert conformal sheets of the Mars Atlas. It consists of four distinctive physiographic regions: 1) part of the northern cratered plain which forms an incomplete annulus around the north polar region, 2) smooth lowland plains of Utopia Planitia across the central and southeastern part of the map, 3) mountainous terrain, in the Nilosyrtis Mensae region south of the lowland plains, consisting of distinct mountains with hummocky surfaces, and 4) cratered plateau in the southwest part of the map, forming the northern part of a large complex cratered region in the mid-latitudes of Mars. In the Casius quadrangle, the cratered plateau is broken by a set of linear to curved parallel-sided canyons on its northern margin.

Eight major geologic units (some of which are subdivided) are defined in the Casius quadrangle: 1) knobby material, 2) plateau material, 3) mottled cratered plains material, 4) hummocky material, 5) plains material, 6) variegated plains material, 7) crater material, and 8) surficial material.

At and near the main erosional scarp of the plateau materials, rounded mountain blocks form isolated peaks or clusters of peaks. They occur mainly north of the erosional frontal scarp of plateau material, in an area of mesalike erosional remnants of plateau material. Three possible interpretations of this unit are: 1) the knobs are material of a distinct stratigraphic unit, below the unit forming the plateau surface and have a deeply dissected upper surface that was exhumed to form knobs as the scarp retreated; 2) the mountains are a resistant lithologic facies of the plateau material, and differential erosion has produced the mountains; 3) the knobs represent erosional remnants of intrusive or extrusive bodies. The possibility of a fourth interpretation, that the knobs consist of the same material as the surrounding plateau material and are remnants of mesas that have lost their flat tops, cannot be completely discounted; however, evidence that they are of different lithology from the plateau material is provided by the presence of knobby material forming mountains which rise above the plateau surface within the outcrop of plateau material. This would suggest that knobby material is more resistent to martian erosion than the plateau material. On this assumption the three possible interpretations listed above can be considered. That knobby material is stratigraphically below the plateau material is suggested in other areas of Mars, for example, on the west side of the Phlegra Montes, where degraded craters have knobby rims. Thus knobs in the Casius Quadrangle may represent material of the cratered terrain under-lying plateau material. Alternatively, knobby material may be a more resistent lithologic facies within plateau material and may, for example, be igneous rocks of volcanic centers emplaced within the plateau material pile. That knobs are post-plateau extrusive bodies appears unlikely but cannot be completely ruled out.

Plateau material

This unit forms a plateau in the southwest corner of the map area and is part of an extensive unit in the martian equatorial region. It appears to overlie a densely cratered surface and the forms of large (as much as 100 km) craters buried by plateau material can be recognized as subcircular depressions. Towards its northern margin, this unit is cut by a system of linear trenches, interpreted as graben, which generally trend about west-northwest. Some form patterns radial and concentric to buried craters. It is likely that these linear trenches have been enlarged by erosion and an alternative explanation is that they represent differential erosion along frature rather than simple graben. The northern margin of the plateau material appears to be an erosional scarp with mesalike outliers of the same material.

Mottled cratered plains material

This unit, defined by Soderblom, Malin, Cutts, and Murray, (1973), occurs in the northern part of the sheet. It has a relatively high frequency of craters smaller than about 20 km and is characterized by its mottled surface at Mariner 9 A-camera resolution (~3 km). The mottled pattern apparently results from the higher albedo of material on the outer rims and, to a lesser degree, the interior of craters against a background of relatively dark material. In general, the mottled cratered plains material is one of the darkest units on Mars and is one of the few units that is characterized by its albedo (Soderblom and others, 1973).

At B-camera resolution (~300 m) the unit is highly variable and includes flat, featureless plains, hummocky surfaces, and reticulated patterns of linear features which subdivide the surface into a network of about 5 km sections. Large craters are generally subdued and lack

surface into a network of about 5 km sections. Large craters are generally subdued and lack central peaks. Some small craters (~5 km) have sharp rim crests but show no other crater structures.

The origin of the mottled cratered plains material is unknown; however, this area is covered by frost during the martian winter months, and it is possible that surface features such as the reticulate patterns result from processes such as frost heaving. The age relations between this unit and the plateau material to the south are not apparent on this quadrangle as the two outcrops are separated by a depression filled with younger plains units.

Hummocky material

This unit lies in front of the cratered plains scarp; it surrounds knobby material and appears to embay the erosional scarp of the plateau material to the south. Hummocky material is characterized by its small, closely spaced, rounded hills of low relief. Its distribution and topographic form as seen on B-frames suggest that the unit is a mantle of erosional debris derived from scarp retreat of the plateau material and mass-wasted debris of knobby material overlying an irregular surface.

Plains material

This unit occupies an east-west lowland belt, known as Utopia Planitia, between the plateau and knobby materials to the south and the mottled cratered plains to the north. These plains are characterized by a nearly featureless surface at A-frame resolution and a relative lack of large craters. At B-camera resolution, the unit is variable and includes moderately hummocky terrain, small sharply defined hills (1-5 km across), finely furrowed terrain, and smooth featureless terrain. In some regions, particularly in the southeast of the map area, small (up to 10 km) sharp rimmed craters are present. The unit is interpreted as eolian material that may have been derived, at least in part, from the erosion of the plateau unit to the south. It is likely that at least some of the unit is contemporary with hummocky material, which may have continued to form by mass wasting as the plains materials were being emplaced.

Variegated plains material

Like the mottled cratered plains, this unit is characterized by streaky albedo markings.

Otherwise, at A-frame resolution, it is almost featureless. At B-frame resolution, it is less smooth and is traversed by occasional ridges similar to lunar mare ridges. The boundary of this unit with the plains material is poorly defined. The presence of mare-ridge-like features at B-frame resolution may indicate that this is a unit of extensive lava sheets.

Crater material

Three crater morphologies are identified on the map: a) relatively fresh craters with wide rims, b) craters with well-defined parrow rims, and c) craters with little or no raised rims.

Three crater morphologies are identified on the map: a) relatively fresh craters with wide rims, b) craters with well-defined narrow rims, and c) craters with little or no raised rim.

The rims of the wide-rim craters extend 0.5 to 2 times the crater diameter from crater edge and are typically hummocky with furrows that radiate from the crater. Around some craters, especially on the lowland plains, the outer margin of the ejecta appears to be marked by a scarp. The scarps may be the result of eolian erosive processes and may reflect the height of effective wind erosion across the lowland plains. In addition, the comparatively blocky ejecta surrounding the crater may serve to "armor plate" the surface, protecting it from wind erosion and leaving it standing at a higher level than the surrounding plains.

The outer flanks of narrow-rim craters have either been worn away or are buried. Some have a small central peak. All crater interiors appear to be partly filled with relatively smooth material that may be equivalent to plains material elsewhere.

The rimless craters consist of large (up to 100 km diameter), flat-floored circular de-

The rimless craters consist of large (up to 100 km diameter), flat-floored circular depressions interpreted as buried craters, expressed at the surface by differential erosion and tectonic activity controlled by the outline of the crater. These craters occur mainly in the southwest part of the quadrangle but may also be present within the outcrop area of the mottled plains material.

Differences in the form of craters from their original morphology result from a) erosion and b) partial burial by later rock units. On the Moon it is possible to determine an erosion chronology for impact craters of different sizes on the basis of their gross morphology and

the surface texture of floor and rim units (Pohn and Offield, 1970). This is possible because photographic coverage usually provides sufficient resolution to distinguish erosion from burial. Erosion results in progressive smoothing of surfaces and lowering of slopes. However, the exposed remnants of buried craters may still have a fresh appearance despite gross differences in crater form caused by burial. On Mars the resolution of Mariner 9 images is not usually sufficient to make these distinctions. On the Moon, impact is the major erosional force, and burial may occur either from engulfment by lavas or from covering by ejecta of adjacent impact craters. On Mars, wind erosion and deposition are added to these processes. Although erosion by impact is uniform on a planetwide scale, as on the Moon, the rate of eolian erosion varies locally, depending on climate, topography, and availability of source material. Craters may also be exhumed by erosion, becoming progressively fresher in appearance as the overlying materials are removed. Thus, on Mars generally, and in the Casius quadrangle in particular, it is difficult to relate differences in gross morphology of craters to their relative ages, except where they occur close together within one rock unit. The narrow-rim craters are probably eroded versions of the wide-rim craters. These crater morphologies represent different degrees of erosion, burial, or exhumation and may have formed in different parts of Mars at different times. Rimless craters may be the same age or older than those mapped as narrow-rim craters. Surficial material

Most regions of the map area have low-albedo patches that cross geologic boundaries and structures without necessarily obscuring them. These markings are interpreted to be the result of eolian activity. Differences in albedo may result from either deposition of particles on the surface or winnowing of an existing surface to change its texture. Markings are generally associated with topographic features and are prevalent on the mottled cratered plains, the plains, and variegated plains. Two types of surficial material are recognized: a) those that form irregular dark patches and b) those that form dark areas characterized by surface lineaments, probably parallel to wind directions.

Several sinuous depressions occur on the Casius quadrangle in the plateau deposits of the southwest. The depressions widen in an apparent downslope direction, and some have short side channels. The channels may be of fluvial origin and contain sedimentary deposits, although surface detail cannot be resolved on the Mariner 9 pictures of this region.

STRUCTURE

The main structural elements occur in the southwest corner of the quadrangle. They consist of linear grabenlike depressions that generally trend west-northwest. Shorter depressions are oriented approximately perpendicular to the main direction and trend northnortheast. Similar structures form subcircular and radial patterns that are probably controlled by craters buried below the mantle of plateau materials.

These structures are part of a fault zone that borders the plateau on its northern margin; west of Casius quadrangle, the faults trend north-west. The origin of these structures is unknown, but they may result from tension on the flank of a broad downwarp or region of

structural instability bordering the depression to the north.

The frontal scarp of the plateau material is in many places parallel to the grabenlike depressions, and it appears that erosion has utilized these planes of weakness in eroding this material. The age of the faulting is interpreted as post-plateau material and pre-hummocky material because the outcrop of the hummocky material crosscuts the depressions.

GEOLOGIC AND HISTORICAL SUMMARY

The surface of Mars is divided approximately into two halves separated by a great circle

that is oblique to the equator. The south half of the planet consists mostly of old and

densely cratered terrain, whereas the north half has more extensive plains units and volcanoes superimposed on older cratered terrain. The northern polar cap retreats and advances with the seasons, and the maximum extent of the frost from the northern can lies in the northern part of the Casius quadrangle. The boundary between the two geologically different hemispheres of Mars runs through the southwestern area of the Casius quadrangle. The densely cratered surface of the southern hemisphere is represented by a cratered unit beneath the plateau material; the remains of this cratered unit may make up the knobby material. The densely cratered surface is considered to reflect the period of intense bombardment in the early history of a thick blanket of plains-forming material, here termed plateau material, possibly of eolian and/or volcanic origin. It is possible that part of the plateau was then downwarped or down faulted to the north below the Utopia Planitia. At this time faulting occurred along the present northern boundary of the plateau material, giving the present grabenlike depressions. Erosion of plateau material resulted in scarp retreat from the north toward the south, leaving behind a debris of hummocky material. This in turn was covered by plains material of Utopia Planitia. The relative age of the mottled cratered plains material and the variegated plains material

is unknown except that they are older than the plains material of Utopia Planitia. It is likely that the surface of the plains is still being modified by eolian processes and that the dark streaks and patches probably represent freshly modified surfaces. Variations in crater density over the surface of the plains suggest that craters are being buried.

REFERENCES CITED

Pohn, H. A., and Offield, T. W., 1970. Lunar crater morphology and relative-age determinations of home probability and the contraction of the plain suggests.

mination of lunar geologic units - Part I, Classification: U.S. Geol. Survey Prof. Paper 700-C, p. C153-C162.

Soderblom, L. A., Malin, M. C., Cutts, J. A., and Murray, B. C., 1973. Mariner 9 observation of the surface of Mars in the north polar region: Jour. Geophys. Research, v. 78, p. 4197-4210.

GEOLOGIC MAP OF THE CASIUS QUADRANGLE OF MARS

INDEX TO MARINER 9 PICTURES

The mosaic used to control the positioning of features on this map was made with the

Mariner 9 A-camera pictures outlined above, identified by vertical numbers. Also shown (by solid black rectangles) are the high-resolution B-camera pictures, identified by italic numbers. The DAS numbers may differ slightly (usually by 5) among various versions of

the same picture.

By
R. Greeley and J. E. Guest

Interior-Geological Survey, Reston Va.-1978-G76435